Sixth Sense Transport

Sixth Sense Transport : Challenges in Supporting Flexible Time Travel

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ABSTRACT

In this paper, we consider the challenges associated with providing a mobile computing system that helps users enjoy a more flexible relationship between time and travel. Current travel plans, especially in Western cultures, are dominated by a strict notion of time. The need to conform to schedules leads to increased pressures for travellers and inefficiencies when these schedules cannot be met. We are interested in exploring the extent to which mobile computing can be used to help travellers relax these schedules and adopt a more opportunistic approach to travel – potentially helping to reduce the environmental, financial and societal costs of modern travel.

1. INTRODUCTION

Travellers often choose single occupancy car journeys over alternative forms of shared transport because of the perceived increase in flexibility, for example in terms of departure and arrival time. Shared transport choices often involve travellers having to organise themselves around the timetables and schedules of public transport. In both cases, time features strongly in travel choices and plans.

Indeed, transport behaviours, habits and practices in contemporary Westernized clock-time cultures are often situated around the notion of time being viewed as a scarce resource, with a high value placed on carving up this commodity into activities running punctually back-to-back [20, 12]. It is particularly significant that these scheduling tendencies are typical of cultures known for engaging in monochronic behaviours [10], where associated social norms prioritize the needs of the individual above the collective.

In this paper, we consider the challenges in trying to develop systems that affect behavioural change in transport habits and practices through the creation of a new form of transport network, based on extending social networking principles to transport users and their individual vehicles. In particular, we consider how mobile technologies can be leveraged to provide users with different ways to relate to time and new ways of understanding the relationships between their own future transport plans and those of others – through highlighting future intersections of the trajectories of people, objects in transit, and modes of transport.

HotMobile'12 February 28–29, 2012, San Diego, CA, USA.

2. THE ROLE OF TIME IN TRANSPORT BEHAVIOUR

The tight coupling between transport and time is a relatively recent event. For example, it was not until the 2nd of August 1880 that legislation enabled the UK to run in one unified time, Greenwich Mean Time (GMT). Prior to this towns and cities across England, Scotland and Wales were entitled to run on their own time that was derived from the solar day. However the advent of the railway network and the growth of the telegraph system meant that by the mid 19th Century major cities such as Liverpool and Manchester began to run on London time. Before long, timetables and station clocks across the United Kingdom began to shift to GMT as more and more trade and communication began to rely on the new technologies of the age.

Since the temporal unification of the UK, public transport has remained firmly aligned to the clock. This adherence to clock time was a significant contributor to the industrial success of the UK through the early part of the twentieth century as the manufacturing, production and distribution of goods ran on a model of clockwork. The movement of people to and from work remains attached to the clock and, even as people began to own their own automobiles through the middle and end of the last century, clocktime has remained the primary system for organising ourselves.

More recently, as society has become networked, and networks have become ubiquitous through the use of mobile telephones, the need to organise our relationships (professional and personal) around the clock has become relaxed. Since mobile phones became popular people have been able to negotiate the time and place of their meetings, leaving it until the last minute to decide when the best time to meet is: "we'll sort it out when we meet up", "I'll text you when I'm ready" [16]. Since Rheingold's studies in Japan in the early 2000's, the mobile phone has since adopted many more capabilities that are beginning to offer an entirely different relationship with clock time. Connected to the internet all of the time, exchanging location based data, social information and managing peoples diaries, the smart phone connects people to each other and the systems that they live and work within in many different ways. Applications such as Foursquare and Facebook don't even require the user to initiate conversations with people who they would like to meet and instead the distribution of a person's location is automatic and offers opportunities for ad hoc meetings that need not require the clock at all.

The sociologist Castell foresaw this "convergence of social evolution and information technologies" and described it as a "space of flows" in which day to day interaction with people and things is liberated from the necessity of temporal and spatial union [5].

Phone based applications are also beginning to change the way people move across cities, apps such as Avego (http://www.avego.com) allow car owners to distribute their routes and activities to people who require a ride. Organised on a dynamic basis across the web through the smart phone app, the system allows real-time ride sharing through a subscription service that allows drivers to be paid for offering lifts to people who needed to go somewhere along their route.

The connection between the driver and the person who needs a ride is mediated by the Avego systems on the network. But it tends to be on the principle of on-demand services which offer opportunities in the present to help people out with a ride and make some money. Castell's vision of a "space of flows" doesn't account for any sense of present, but values the past in order to offer different presents and futures. We believe that adopting this type of flexible relationship between time and travel offers significant potential to change travel behaviour.

3. THE SIXTH SENSE APPROACH

Our proposal is to develop a system of the form shown in Figure 1 that combines a wide range of information to provide transport users with a glimpse of future mobility patterns – enabling them to understand their own travel plans in a wider context and supporting new forms of opportunistic travel sharing. We call our system *Sixth Sense Transport (6ST)*.

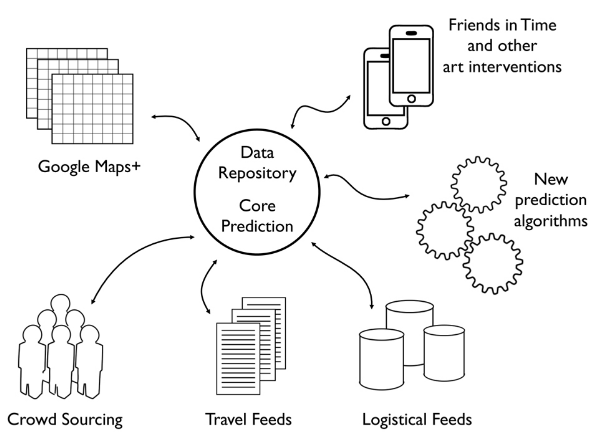

Figure 1: Overview of the 6ST Platform

We envisage that information on travel patterns can be obtained from several different types of source. In the case of individual users, they can contribute their location information either explicitly in the form of posted location updates, or implicitly through tracking applications – operating on the phone or in the network. Moreover, we expect that sources such as TripIt schedules and on-line calendaring applications can be mined to help provide more information on individual user travel patterns. Information can also be gleaned from public data feeds such as train timetables and, in the case of organisations, from operational databases (e.g. vehicle or parcel tracking logistics systems).

These information feeds will be processed and predictions made of future mobility patterns. Our aim is to make our system "open" in the sense that researchers are able to contribute new prediction algorithms that can be used to improve the overall performance of Sixth Sense Transport or customised for specific domains. Similarly, we anticipate the predictions we make would be used by a wide range of transport users. This would include individual travellers or organisations. Once again, we anticipate making this open to new forms of visualisation and new uses such as artistic endeavours.

Key to our approach is the idea of using objects within the transport network, especially vehicles but also parcels and travellers themselves, as conduits for the flow of information. In essence, this involves creating an "internet of things that move" – enabling the exchange of information through the physical exchange, or encounter, of physical objects.

It is worth highlighting at this point that we are not concerned with the underlying mechanism used for the exchange of information (so we do not rely on, for example, vehicular ad-hoc networks) but rather we wish to make sure that physical encounters can stimulate appropriate information exchanges in the virtual world.

4. SCENARIOS

To illustrate the potential of our approach, we consider three distinct sets of scenarios - each selected from a different broad area of transport use. In each scenario, we show how our Sixth Sense application can be used to help users benefit from a more flexible relationship between time and transport.

4.1 Tourism

Sam and her family have just arrived in southern France at the campsite where they will be spending the next 10 days. Once the tent is pitched Sam checks her sixth-sense application. Shifting the display backwards and forwards in time she sees trails leading to and from the campsite to popular attractions and local amenities. Some of her fellow campers are bringing back groceries from the nearest out-of-town hypermarket and she adds a few items to a shared shopping list. The friends that her children have already made at the camp playground are heading to the beach tomorrow. Sam doesn't know their name but she does know which campsite pitch they are occupying and she tags their car to see if they are interested in meeting up.

Tourism has long been an area of intense research for mobile computing researchers (e.g. GUIDE [6]). In our scenario we focus on the travel experiences of visitors to campsites. In contrast to many US campsites, camping in Europe is a relatively organised activity with campsites being densely populated. However, despite many factors that would naturally bring campers together very few choose to coordinate their travel activities with others. Some of this is due to the obvious problem of establishing trust relationships in the relatively short time most people stay at a campsite. We envisage a scenario in which campsite users choose to share travel information through a sixth sense application. At its simplest this would produce traces of common travel patterns - enabling users to see, in a suitably aggregated and anonymous form, where their fellow campers travelled to during their stay. Adding features such as location-based notes, sharing of travel experiences and additional travel feeds can obviously provide richer experiences [4, 2]. However, we believe that the real potential comes from providing an ability to see travel patterns – both historical and predicted. Such patterns then provide obvious means of tourists coordinating activities.

4.2 Daily Travel Activities

Tom is doing the school run again and, as usual, he is late this morning. His school has subscribed to the sixth sense travel application and Tom is able to see the flows of cars, buses and walking-buses heading towards the school gates. Scrolling forwards he can see that his intended plan of walking the kids to school is going to mean they miss the school bell. However, he can see that a 5 minute drive will enable him to intersect with one of the school's walking trains – enabling him to drop the kids off so they can benefit from walking at least part of the way to school while he can continue on his way to work.

In contrast to tourism and business travel there has been much less research into support for routine travel activities. Indeed, research has shown that many users do not use any form of electronic travel information system when on routine journeys such as daily commutes or school runs. However, many of these journeys take place in congested urban areas and contribute significantly to carbon emissions. The scenario above demonstrates how an awareness of other's travel patterns allows for new forms of planning and journey optimisation.

The key point here is that the user is not simply consulting a timetable that provides them with a set of fixed arrival and departure times to specific points - rather they are able to see in real-time multi-modal travel options and to combine them in new, opportunistic ways.

4.3 Logistics

4.3.1 Business to Consumer

Chloe does a lot of shopping on-line. She misses around 60% of her home deliveries, typical of UK households [1, 14], and spends a lot of precious time driving to carriers' depots on Saturdays to collect packages which collectively costs the UK home shopper around 259 million pounds per year [8]. As she orders her spring bulbs on-line, she specifies that she would like them delivered to a convenient drop-box and shares her SixthSense predictions with the delivery company. As she pulls into the local shopping centre the following day, she receives a notification on her phone that her bulbs have just arrived and are waiting for her at the drop-box in the car-park.

Research suggests that unsuccessful home deliveries can be detrimental to the environment [23] and that using a car to make a 25-mile round trip to collect a missed delivery from a carrier's depot will produce around 8,348g CO2 (or the equivalent of 26 re-delivery attempts by a delivery van, when half of first and second-time deliveries have failed) [7]. There is increasing interest in optimising the delivery of packages to both domestic customers (given current failed first-time delivery rates) and businesses (with time critical deliveries into often congested urban centres).

Drop-boxes provide a partial solution to the problem - enabling users to specify a delivery location (typically train stations, industrial estates or city squares) where the package can be left, reducing the number of new journeys required (particularly those involving the householder visiting the carrier's depot which are the most environmentally costly) [19]. However for many consumers there is little incentive to use drop-boxes as they imply, in consumers' minds, additional delay in receiving the package, and often ill-perceived security concerns [11].

Sixth Sense raises the interesting possibility of logistics companies leveraging drop-boxes to enable them to deliver to a person rather than to an address – thereby reducing the overall delivery time and providing a clear incentive for consumers to use the technology. There are obvious parallels between this new paradigm for logistics and the shift that has taken place in the telephone industry in which the advent of mobile technology fundamentally changed the perceived end-points of phone calls (from calling a location to calling a person, independent of their location).

4.3.2 Business to Business

Dave is a photocopier engineer working for a major electronics manufacturer. He uses drop-boxes to get parts from the regional distribution centre (RDC) delivered closer to his daily service jobs, which cover clients all over the South East. This saves him the mileage associated with travelling back to the RDC periodically to collect spares. With his SixthSense prediction, he also has visibility of his fellow engineers and can see how certain parts might be able to reach him at the current or subsequent jobs by making connections between engineers vans, lockers and the RDC in the future. Through SixthSense, he can also determine whether he should swap certain jobs with other engineers once he has made the initial diagnosis of the problem, given their current and likely future position in space and time.

This scenario shows that by sharing predictions of travel patterns with others, it would be possible for engineers to collaborate and use their time more effectively. Sixth Sense also supports the idea of giving more autonomy to the driver in decision making (specifically in the mobile service engineering sector) to better meet customer needs and reduce the overall transport footprint.

5. CHALLENGES

Providing mobile computing support for moving from a clock based society, that has only ever known how to relate to the flow of transport through a fixed timetable, to a fluid and relational system that highlights the opportunities for finding links in the transport network in order to offer shares or links with other people, raises a wide range of new challenges for the research field.

5.1 Travel Prediction and Planning

Predicting aggregate traffic patterns is a well studied field and transport planners are able to produce detailed predictions of future traffic patterns within the transport network. However, predicting individual travel patterns across different transport types (i.e. foot, car, bus, train) is a much more demanding problem.

Existing research has focused on predicting movement patterns in a number of contexts, e.g. with the aim of producing power savings by reducing the number of GPS readings uploaded from a mobile device, or improving network performance by predicting network handoffs.

Path planning for an object to move from its current location to a destination among an environment with obstacles is a well-studied problem in robotics [9]. There are many existing approaches to this problem for finding an optimal path based on distance. Other methods also exist for handling moving obstacles [15], which can be considered as having time as another dimension in the planning space.

The challenge in realising a Sixth Sense style application is in providing sufficiently accurate predictions of individual mobility patterns that travellers can adjust their travel plans to take advantage of opportunistic encounters. Of course in so doing we are introducing increased uncertainty into travel schedules. This may cause anxiety amongst travellers and research is needed into achieving the correct balance between the stress caused by uncertainty and the pressure of perpetual cognitive monitoring of the extent to which any activity/journey is on track to be completed within the available time slot (which is typically experienced as subjective time pressure). Taken in isolation, subjective time pressure has status as a daily social stressor, yet cumulatively chronic time pressure is assigned a mediating role in detrimental health related quality-of-life outcomes [17].

5.2 User Interaction and Visualisation

Smart phones provide a rich visual platform to offer users a number of insights to the vast amount of data that we can collect. To handle such high-dimensional data, we need to develop simple low-dimensional interfaces for the user to perceive the right amount of information in an efficient manner. The inputs to the visualisation module might include user-defined filters, the screen resolution level, and a number of "object tags" such as the location, time, and type of a vehicle. A visualisation module would need to act as a filter to these inputs to generate output data that may include the position, time, shape, size, and colour of location indicators [13]. There are two goals of visualisation that we should achieve. Firstly, the visualisations should convey information about the data and emphasise important aspects of it. Second, they should support effective and efficient reasoning about the existing data to enable users to base important personal transport decisions on the information they provide.

One challenge that we identify is that the predicted future traffic patterns are based on past behaviour and are therefore uncertain. While one recent previous work on this topic [18] uses size, or colour, or traditional errorbars to visualise the uncertainty of values, there seems to be no consensus of what method is best, as different methods are needed depending on the data being visualised. Visualising uncertainty is an important problem in mobile computing and results in this area could help inform the design of a wide range of applications that need to reflect uncertain context information.

Another key problem for our applications is in showing four dimensional data with lots of details on a screen with a limited size. To achieve our visualisation goals, it is therefore important to decide how to filter the content to use this limited resource carefully and display only pertinent information to the user. We also need to have easy-to-use interfaces for the user to specify inputs and contribute data to the system. For example, interfaces are required to represent and, crucially, to correct predicted data from past, present and potential futures about the location and timings of objects in the system.

Displaying different granularities of information for different resolution levels is another challenge. As the user "zooms in", it would make sense to display icons to represent individual cars or buses. However, as the user "zooms out", it would make sense to cluster groups of cars together and only visualise the major streams of traffic.

The key challenge for user interaction and visualisation is in emphasising important aspects of *four dimensional uncertain data* on devices with limited screen real estate.

5.3 Tagging

A particular characteristic of the Sixth Sense approach is the acknowledgement that both everyday "things" and human beings have the potential to be "packets" of data in the network. For example, cars offer data about where they have been, where they are likely to go, and their capacity to hold more people. Goods can also offer data regarding their movements from one place to another.

One critical dimension that the Sixth Sense approach requires is the ability to read and write to the network to allow the network to best understand the needs of people to move themselves, other people and also artefacts across space and time. Whilst social networking interfaces have used websites and apps as the primary interface to engage with one and another, we are concerned with actual people and things that exist in the physical space as well as those being documented in the virtual space. Interfacing with physical artefacts is becoming common place however through the use of barcodes as a means of retreiving information from the internet. Traditionally associated with barcode readers found at supermarket tills, smart phones have adopted the facility to scan barcodes through specific apps that make use of the onboard camera. Able to scan traditional barcodes and Quick Response (QR) codes, the public are becoming aware of the ability to scan physical artefacts. More recent projects such as the UK-based Tales of Things initiative has promoted the use of QR codes as having a write-back facility [3, 21, 22].

We anticipate using barcodes for artefacts that require movement through the network as the interface for a carrier to better understand where it needs to go next: scanning a box may tell the carrier to navigate in a particular direction in order to move toward the box's destination, but also (and perhaps more importantly) tell the Sixth Sense platform who is carrying it and where it is going since the carrier will be equipped with location services on their smart phone. Cars offer the most radical opportunity for interfacing with the flow of people and things, and they have been equipped with tags for much longer than products available in shops. Car registration plates are easily identified by image recognition systems, but are also easy to remember and type as well. We envision using the car number plate as an interface to allow members of its network to record data about the car to the network, but also retrieve data from the service. These gateways to the network that exist physically in the street offer a material substrate upon which a space of flows can be constructed.

5.4 User Adoption

Like many systems based on social networking and crowd-sourced data our approach relies on us establishing a critical mass of users. This is required because we need to build up accurate pictures of past, present and future travel patterns to act as the basis for our visualisations. Clearly, establishing such a user base will not be trivial. In particular, we can identify two challenges relevant to this domain (in addition to all the normal problems of building a large user base). Firstly, engaging with the system is likely to raise serious privacy concerns among users. Mobile users have become relatively accustomed to sharing their location through applications such as Google Latitude but most are resistant to any form of "tracking" (the distinction again being related to time - instantaneous access to a user's location versus continuous tracking of a location over an extended period of time). The integration of social networks and transport networks raises important and interesting problems.

The second challenge is to develop the right social conditions and models of trust that will work for our proposed system. In particular, we are relying on users to share transport resources based on new opportunities highlighted by the system. Sharing transport has long been seen as a partial solution to transport problems, typically in the form of lift sharing schemes, yet there is often reluctance by users to engage in transport sharing. The important question to address is how trust can be fostered in a travel system that echoes the openness of social networking systems.

Addressing these challenges will be crucial to the success of our system and will require innovative new forms of privacy protection and establishment of trust relationships. There is also the important issue of creating an appropriate reward structure to motivate and encourage users to participate in the system, both in providing data to the system and retrieving data from it. We believe that it will be important to allow people to see their contribution to the system with clarity. In particular, in order to encourage adoption, users should be able to identify their contribution to the system and its contribution in helping to make connections and aid travel. In addition, this raises the question as to what extent a system should display more or less information so as to attract a user into feeling like they are making valuable contributions.

Finally, we note that encouraging user adoption may be easier for some classes of user and for some of our scenarios than others. For example, it may be possible to motivate consumers to contribute schedules to help with delivery of their parcels more readily than to provide comprehensive traces to facilitate opportunistic car sharing.

6. CONCLUSION

Environmental and financial concerns demand that we begin to explore radically new ways of organising our transport systems. In this paper, we have explored the challenges that arise when considering one such radical, new approach based on the concept of trying to offer transport users new ways of perceiving and relating to time. These challenges relate specifically to the field of mobile computing and if addressed successfully could enable the creation of new systems that fundamentally change the way we think about time and its relationship to transport.

7. ACKNOWLEDGEMENTS

The research leading to these results was partially conducted under the auspices of the RCUK funded Sixth Sense project.

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